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MAY 2 4 2002
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Lignin

STAGE I — Base-catalyzed depolymerization (BCD)

Medium: water
Catalysts: (a) dilute (1 - 5 wt%) aqueous NaOH; (b) solid superbase (e.g., CsX-type zeolite); or (c) combinations of (a) and (b)
Temperature, °C: 300 - 340

↓

Depolymerized lignin
(mixture of alkylated phenols, alkoxybenzenes, and alkoxyphenols; and hydrocarbons)

STAGE II — Single-step hydroprocessing (HPR), comprising simultaneous (a) exhaustive hydrodeoxygenation (HDO); and (b) mild hydrocracking (HCR)

Sulfided co-catalyst systems:
(a) MMo/Al_2O_3 plus
(b) MMo/SiO_2-Al_2O_3-zeolite
where M (promoter) = Ru, Re, Co, Fe, Cr, Pt or other VI - VIII group metals; and combinations thereof
Temperature, °C: 350 - 390
No solvent

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C_7 - C_{10} alkylbenzenes (approx. 80-90 wt%);
C_5 - C_{10} branched paraffins plus C_6 - C_{10} alkylated naphthenes (approx. 10 - 20 wt%)

Figure 1a Schematic flow diagram of the two-stage (BCD-HPR) process for conversion of lignin to C_7 - C_{10} alkylbenzenes as gasoline blending components according to the present invention.

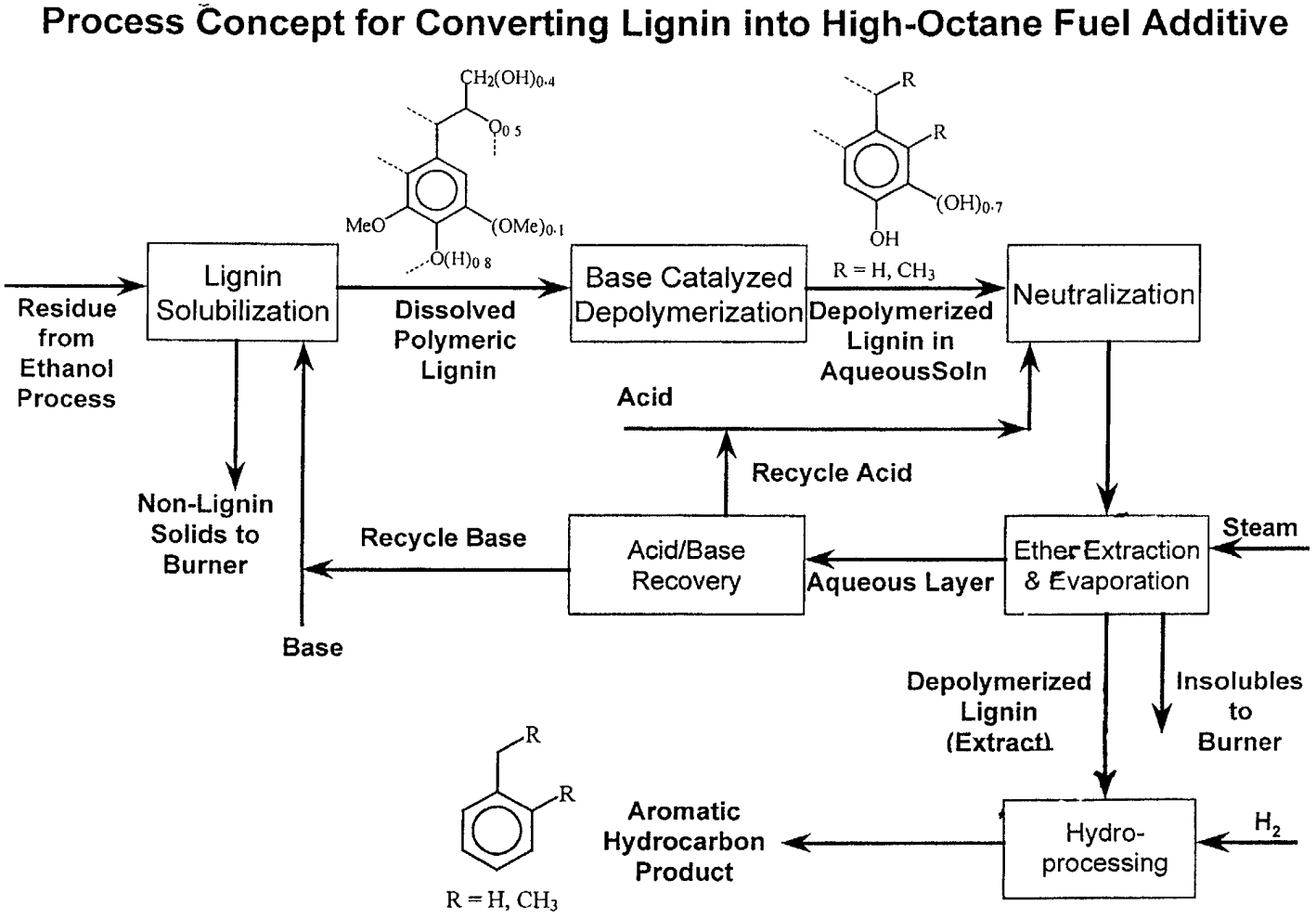
Process Concept for Converting Lignin into High-Octane Fuel Additive
Residue from Ethanol Process
Lignin Solubilization
Dissolved Polymeric Lignin
Base Catalyzed Depolymerization
R = H, CH3
Depolymerized Lignin in AqueousSoln
Neutralization
Acid
Recycle Acid
Non-Lignin Solids to Burner
Recycle Base
Acid/Base Recovery
Aqueous Layer
Ether Extraction & Evaporation
Steam
Base
Depolymerized Lignin (Extract)
Insolubles to Burner
Aromatic Hydrocarbon Product
Hydro-processing
H2
R = H, CH3

Figure 1b

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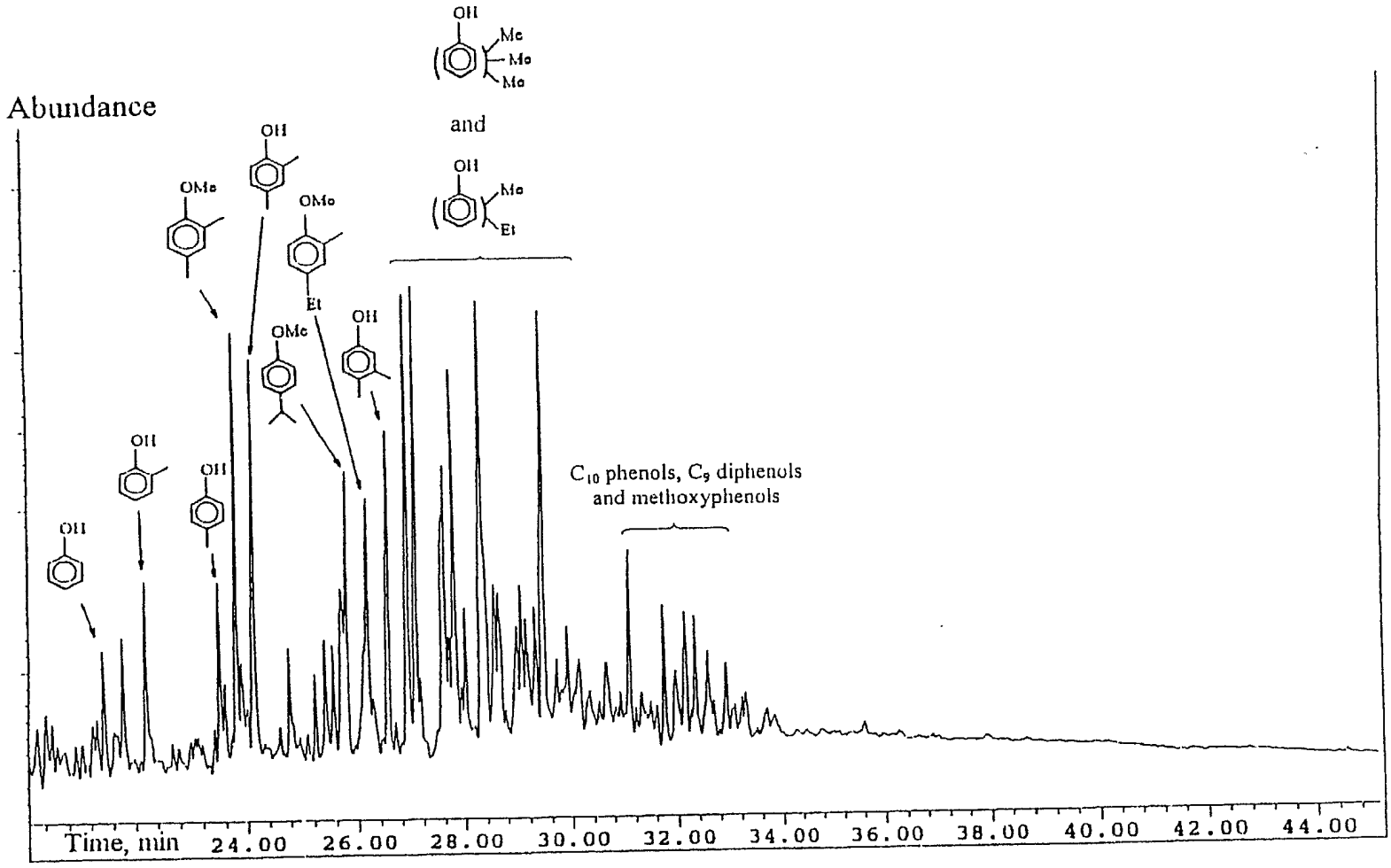

Figure 2. Example of GC/MS analysis of depolymerized (BCD) product from Repap lignin.

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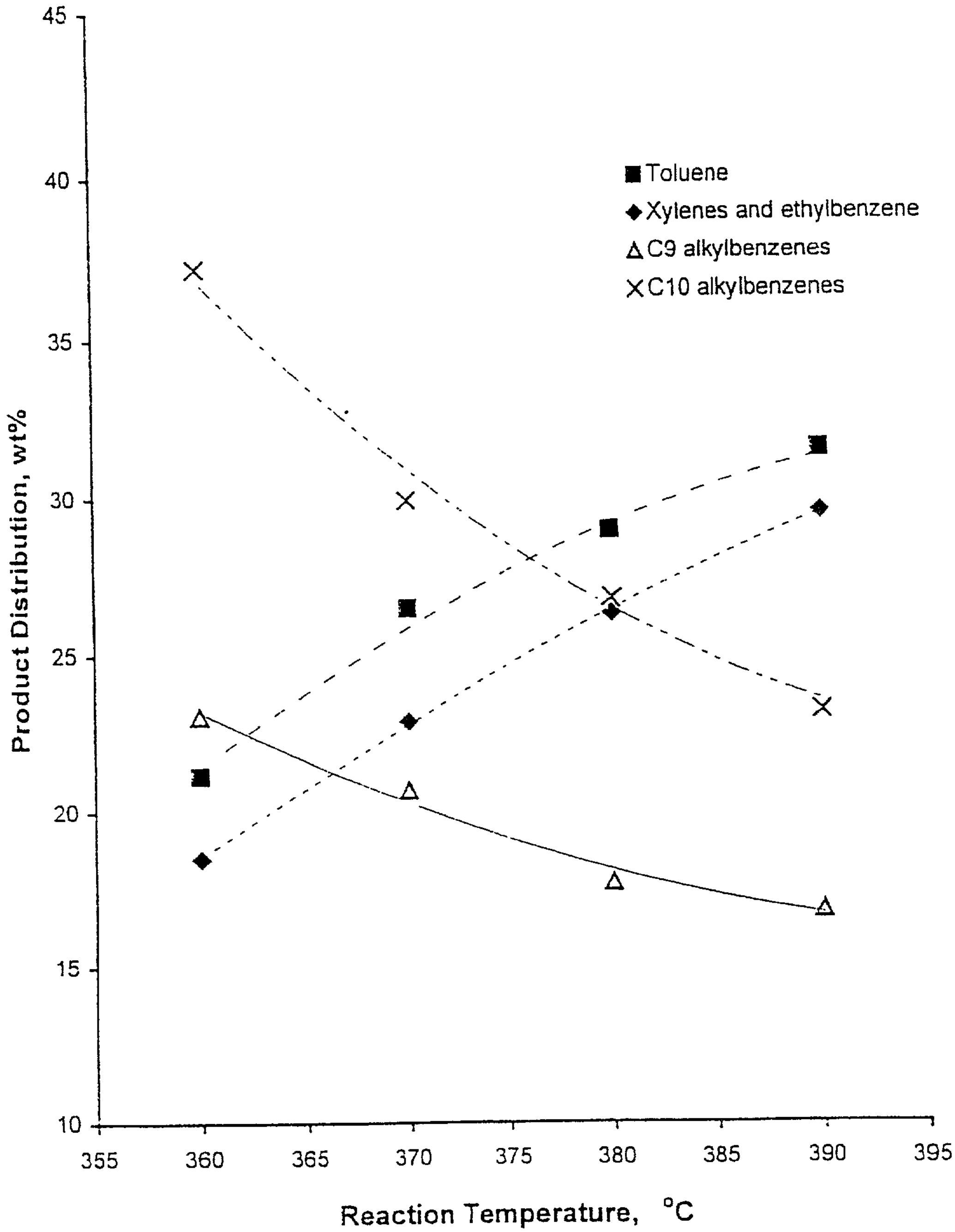

Figure 3. Change in Composition of C_7 - C_{10} Alkylbenzene Products from BCD-HPR of Repap Lignin, as a Function of HPR Reaction Temperature

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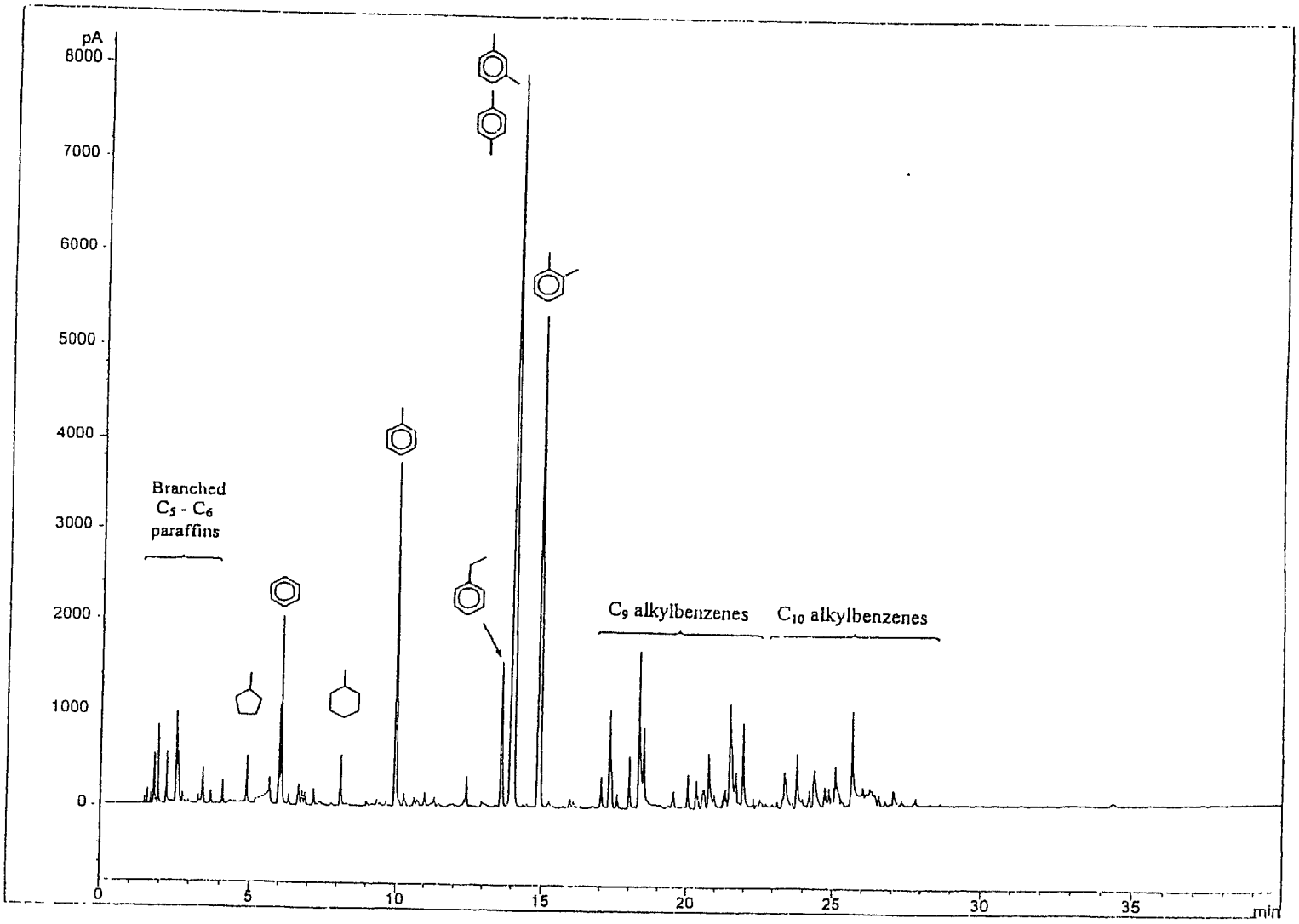

Figure 4. Example of GC/MS analysis of HPR product from depolymerized Repap lignin (HPR temperature, 380 °C; H_2 pressure, 500 psig; LHSV = 4 h^{-1}; HCR/HDO co-catalyst wt. ratio, 1 : 9).

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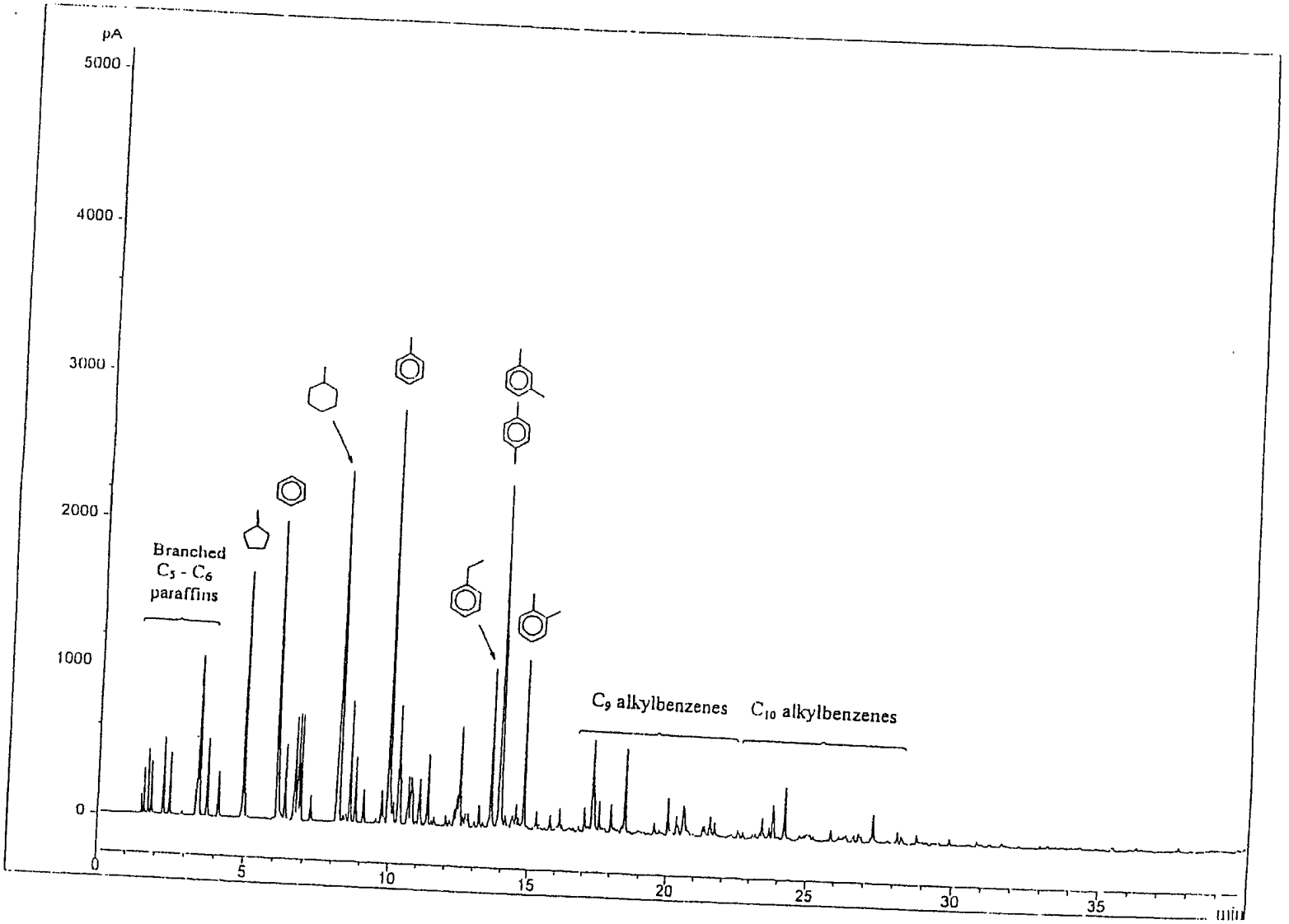

Figure 5. Example of GC/MS analysis of HPR product from depolymerized Repap lignin (HPR temperature, 380 °C; H_2 pressure, 1500 psig; LHSV = 4 h^{-1}; HCR/HDO co-catalyst wt. ratio, 1 : 4).